

Santa's Toy Factory

Christmas Time has finally arrived and Santa made the last updates on his “Naughty or Nice” list for this year. While most of the presents are made in the main factory, the presents for the best of the children are to be manufactured separately in Santa’s secret underground workshop. To award these children, their presents will be customized according to their preferences.

In this workshop, the gifts for wonderful boys and delightful girls are made in separate chambers. The boys’ presents are custom-built in the Blue Chamber, and the girls’ presents are custom-made in the Red Chamber. After each gift is specially personalized, the presents have to be transferred back to the main factory for gift-wrapping through a secret tunnel. Back at the main factory, the presents for boys and the presents for girls are wrapped in separately, in the Blue Room and the Red Room respectively.

As the manufacturing processes began, Santa thought back to how many of these special gifts for the best behaving children were accidentally transferred to the wrong Wrapping Room last year. Since these gifts are for the best of the best, he is determined to find a solution to make sure no more mistakes will occur this year. Even though he thought long and hard, Santa could not think of a way to transfer the presents through the secret tunnel which ensures that all the boy presents made in the Blue Chamber will be effectively transferred to the Blue Room, while all the girl presents assembled in the Red Chamber will be successfully transferred to the Red Room.

In desperation, he asked his intelligent engineering friends, the Three Little Pigs, for help.

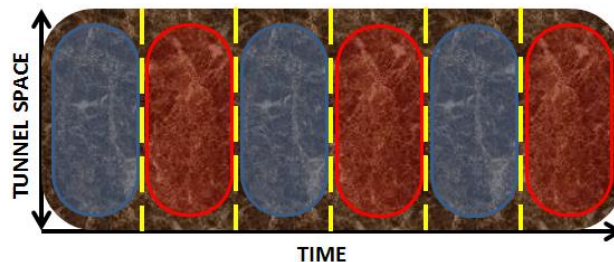
After listening to the problem, each of the Three Little Pigs came up with a suggestion:

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Essay #1: TDMA vs. FDMA vs. CDMA

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(1) The First Pig, who specializes in TDMA (Time Division Multiple Access), suggested that Santa set up a time duration dedicated to transfer only one type of



presents at once. For example, if Santa decides to set the duration of each interval to be one minute, during the first minute, the secret tunnel will be used solely to transfer boy presents from the Blue Chamber to the Blue Room. Subsequently, during the next minute, the secret tunnel will be used solely to transfer girl presents from the Red Chamber to the Red Room. In other words, the tunnel will alternate between transferring only boy presents and transferring only girl presents every minute. Since only one type of present is being transferred during each time interval, the presents are also less likely to be mixed up during the transfer and end up in the wrong Wrapping Room.

Using TDMA has two main advantages. First, collisions and mix-ups can be eliminated since only one type of presents is transferred at a time. Also, the time is shared fairly between both types of presents.

However, there are also two main disadvantages. First, since the total time to transport presents is divided in half for each type of present, the rate of transfer will be limited. A second drawback is that each type of present must always wait for its turn in the sequence to transfer its presents, which could result in significant delays. Imagine during a particular interval for transferring boy's presents, there might not be any boy presents that are ready to be transferred. However, on the other side, lots of girl presents have already been completed and are waiting for their turn in the sequence.

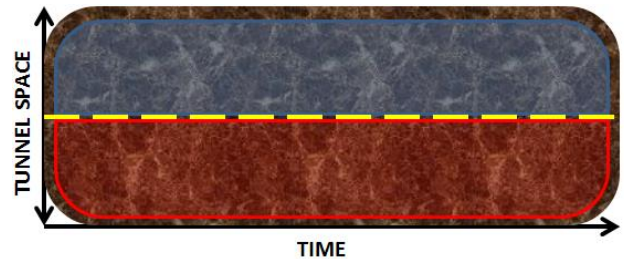
(2) The Second Pig, who specializes in FDMA (Frequency Division Multiple Access), suggested that Santa divide the secret tunnel in half. By dedicating half of the tunnel to transfer boy presents from the Blue

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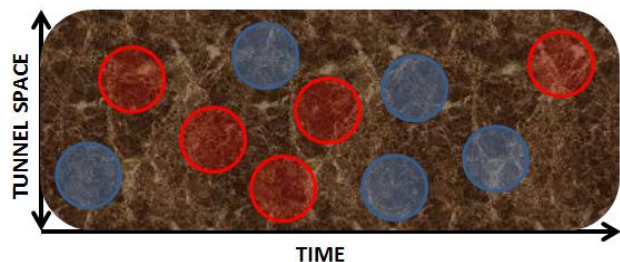
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Chamber to the Blue Room, and dedicating the other half of the tunnel to transfer girl presents from the Red Chamber to the Red Room, the presents are less likely to be mixed up during the transfer and end up in the wrong Wrapping Room.



FDMA shares practically all the advantages and drawbacks of TDMA. For instance, it also avoids collisions and divides the tunnel equally (in space instead of time). In addition, since the total tunnel space is divided in half, the space to transfer each type of present will be limited. However, even though this technique eliminates the delay and waiting problems of TDMA, it creates another drawback. In FDMA, if the tunnel has to transport more types of presents, it is more likely that different types of presents may interfere with each other. This is because adding every new tunnel user reduces the spacing even more, which may cause some of the bigger presents to accidentally travel into the space dedicated to the other type of present and be mistakenly identified.

(3) The Third Pig, who specializes in CDMA (Code Divisional Multiple Access), suggested that Santa set up a coding system which assigns a different



code for each type of present. For example, if blue stickers are put on every boy present, and red stickers are put on every girl present, as long as the workers of the Blue Room and the workers of the Red Room know the code, the presents will be able to transmit simultaneously and successfully. This method not only keeps the advantages from TDMA and FDMA, it solves their main problems as well. Since all the presents will be coded in advance with a code recognizable to the receiver, all gifts can be transferred

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simultaneously and successfully, with no time and space wasted. However, the code for each of type of present must be designed carefully. If the codes are too similar, the receiving end might be unable to differentiate the different types and result in some errors.

The three little pigs glared at each other. Each of them thinks that their solution is the best way to solve Santa's problem. In chorus, they turned to Santa to hear his opinion. While Santa considered the three options available, suddenly, the whole world started to shake. The biggest earthquake of five hundred years has struck the North Pole! Sadly, the secret tunnel connecting the secret workshop to the main factory could not withstand the catastrophic shaking and collapsed! Fortunately, all the elves working in the workshop at the time of the earthquake were rescued within hours afterwards. However, it would be months before the workshop and the tunnel can be used again. Dejectedly, Santa declares that all toys will have to be made in the main factory this year.

As he orders his elves to start working again, Santa made a mental note to enroll in the "Introduction to Computer Networks" course so he'll be able to learn more about different ways of Multiple Access before he has to make the important decision next year.

References

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